

MASSACHUSETTS—RHODE ISLAND COASTAL BASIN
GLOUCESTER, MASSACHUSETTS

BABSON RESERVOIR DAM

MA 00187

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM



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DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. 02154

NOVEMBER 1978

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ABSTRACT (Continue on reverse side if necessary and identify by block number) The dam consists of an earth embankment approximately 630 feet long and 40 ft. high with an ungated spillway about 40 feet long at the center of the structure. Babson Reservoir Dam is currently classified as having a "high" hazard potential in the Corps of Engineers National Inventory of Dams. The test flood is the PMF.		



DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02154

REPLY TO
ATTENTION OF:

NEDED

JAN 22 1979

Honorable Edward J. King
Governor of the Commonwealth of
Massachusetts
State House
Boston, Massachusetts 02133

Dear Governor King:


I am forwarding to you a copy of the Babson Reservoir Dam Phase I Inspection Report, which was prepared under the National Program for Inspection of Non-Federal Dams. This report is presented for your use and is based upon a visual inspection, a review of the past performance and a brief hydrological study of the dam. A brief assessment is included at the beginning of the report. I have approved the report and support the findings and recommendations described in Section 7 and ask that you keep me informed of the actions taken to implement them. This follow-up action is a vitally important part of this program.

A copy of this report has been forwarded to the Department of Environmental Quality Engineering, the cooperating agency for the Commonwealth of Massachusetts. In addition, a copy of the report has also been furnished the owner, City of Gloucester, Public Works Department, Poplar Street, Gloucester, Massachusetts 01930, ATTN: Mr. Robert O'Brien, Director.

Copies of this report will be made available to the public, upon request, by this office under the Freedom of Information Act. In the case of this report the release date will be thirty days from the date of this letter.

I wish to take this opportunity to thank you and the Department of Environmental Quality Engineering for your cooperation in carrying out this program.

Sincerely yours,


JOHN P. CHANDLER
Colonel, Corps of Engineers
Division Engineer

Incl
As stated

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PHASE I INVESTIGATION REPORT
NATIONAL DAM INSPECTION PROGRAM

Identification No.: MA 00187
Name of Dam: Babson Reservoir
Town: Gloucester
County: Essex
State: Massachusetts
Stream: Tributary to Mill River
Date of Site Visit: 8 September 1978

BRIEF ASSESSMENT

Babson Reservoir is located on Alewife Brook approximately one mile north of the City of Gloucester, Mass. A dam, spillway and intake works were constructed in 1930 to impound a water supply for the City. The dam consists of an earth embankment approximately 630 ft. long and 40 ft. high with an ungated spillway about 40 ft. long at the center of the structure. The only outlet is a 24-in. pipe from a gate house intake located in the upstream slope.


Babson Reservoir Dam is currently classified as having a "high" hazard potential in the Corps of Engineers National Inventory of dams.

Based on a visual examination of the structure, the earth embankment and spillway are in good to fair condition. There was no evidence of settlement, lateral movement or other signs of structural failure or other conditions which would warrant urgent remedial treatment.

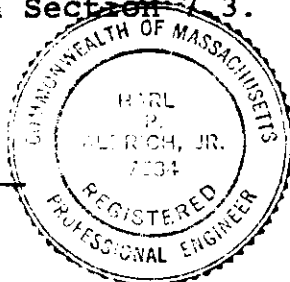
Based on size and hazard classifications in accordance with Corps of Engineers guidelines, the test flood for this dam is the Probable Maximum Flood (PMF). The spillway has a capacity of 1790 cfs with flashboards removed and can pass the PMF outflow of 1530 cfs (750 csm) with the water level 0.6 ft. below the top of the concrete core wall.

Within two years after receipt of this Phase I Inspection Report, the City of Gloucester, owner of the dam, should engage a registered professional engineer to determine embankment slope stability during an earthquake event and implement the results of this evaluation. The owner should also implement the remedial measures, including removal of trees and brush from the downstream slope and repair of deteriorating concrete, as outlined in Section 7.3.

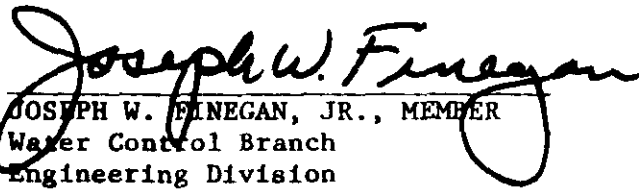
HALEY & ALDRICH, INC.
by:

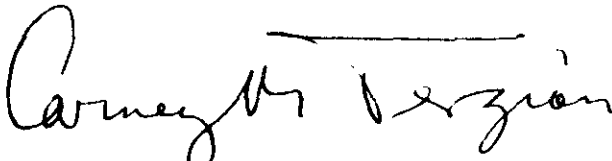


Harl Aldrich
President




This Phase I Inspection Report on Babson Reservoir Dam has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgment and practice, and is hereby submitted for approval.


JOSEPH W. FINEGAN, JR., MEMBER
Water Control Branch
Engineering Division


CARNEY M. TERZIAN, MEMBER
Design Branch
Engineering Division


JOSEPH A. MCELROY, CHAIRMAN
Chief, NED Materials Testing Lab.
Foundations & Materials Branch
Engineering Division

APPROVAL RECOMMENDED:


JOE B. FRYAR
Chief, Engineering Division

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, DC 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I Investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I Investigations are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the test flood is based on the estimated "probable maximum flood" for the region (greatest reasonably possible storm run-off), or a fraction thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aide in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

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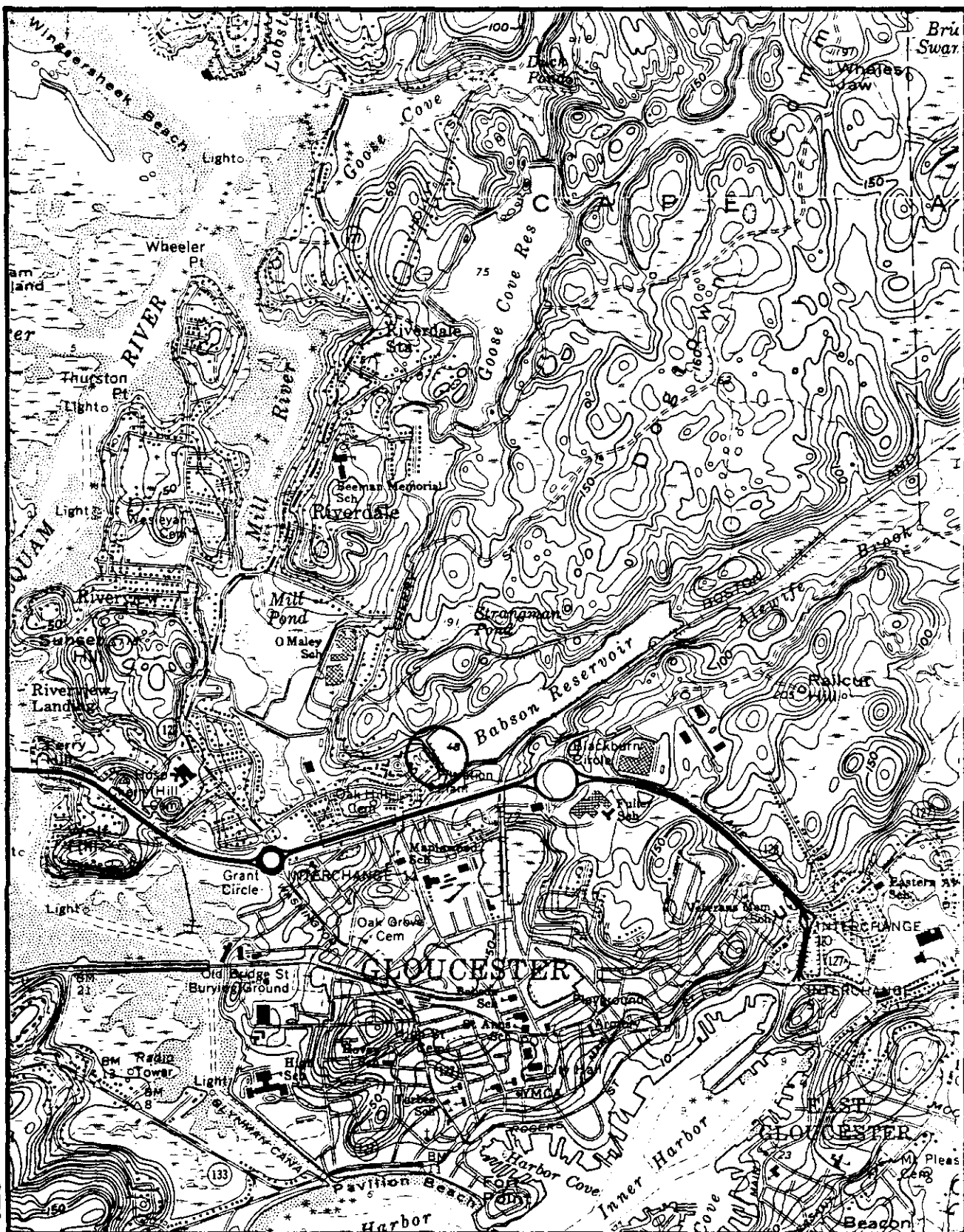
APPENDIX D - OUTLINE OF DRAINAGE AREA AND
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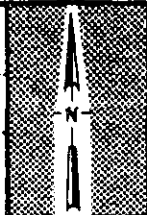


1. Overview of crest and upstream slope from left abutement.

FILE NO. 4160 A18



DAM: Babson Reservoir
IDENTIFICATION NO. MA 00187



LOCATION MAP
USGS QUADRANGLE
GLOUCESTER, MA.
APPROX. SCALE: 1" = 2000'

PHASE I INVESTIGATION REPORT
NATIONAL DAM INSPECTION PROGRAM
BABSON RESERVOIR DAM
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SECTION 1-PROJECT INFORMATION

1.1 GENERAL

A. Authority. Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a National Program of Dam Inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region.

Haley & Aldrich, Inc. has been retained by the New England Division to inspect and report on selected dams in the State of Massachusetts. Authorization and notice to proceed were issued to Haley & Aldrich, Inc. under a letter dated 26 April 1978 from Colonel Ralph T. Garver, Corps of Engineers. Contract No. DACW33-78-C-0301 has been assigned by the Corps of Engineers for this work. Camp, Dresser & McKee, Inc. was retained as consultant to Haley & Aldrich, Inc. on the structural, mechanical/electrical and hydraulic/hydrologic aspects of the investigation.

B. Purpose. The primary purposes of the National Dam Inspection Program are to:

1. Perform technical inspection and evaluation of non-Federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-Federal interests.
2. Encourage and prepare the states to initiate quickly effective dam safety programs for non-Federal dams.
3. To update, verify and complete the National Inventory of Dams.

1.2 PROJECT DESCRIPTION

A. Location. The dam impounds Babson Reservoir on Alewife Brook, a tributary to the Mill River, in the City of Gloucester, Massachusetts. The dam is located on the southwest end of the reservoir, as shown on the Location Map, page vii.

B. Dam and Appurtenances. The Babson Reservoir Dam consists of an earth embankment, an ungated concrete-faced spillway near the middle of the embankment, and a gate house structure. The total length of the dam is approximately 630 ft. The "Site Sketch Plan", Appendix C-1, shows the general configuration of the dam and appurtenances. More detailed plans and sections are shown on construction drawings in Appendix B.

The right and left embankments are approximately 40 ft. high. Slopes are 2 horizontal to 1 vertical on the downstream side. The upper part of the upstream side is sloped 2.5 to 1, becoming 2.75 to 1 below a berm at El. 45. The embankments contain a 15-in. thick concrete core wall bearing on rock or interlocking steel sheet piling driven to rock, as shown on the section in Appendix B-10. The lower part of the upstream slope is protected by riprap and the upper part is paved with reinforced concrete. There is a gravel road on the crest of the left abutment and the downstream slopes are wooded.

The spillway is a broad crested weir with 2 horizontal to 1 vertical discharge slope supported by rock fill founded on bedrock. It is 40 ft. long with a crest at El. 55, 5.8 ft. below the top of the concrete core wall. Three rows of four 6-in. tile drains exit on the discharge slope. A cross-section through the spillway is also shown in Appendix B-10.

A gate house structure is located left of the spillway on the upstream slope of the dam embankment. The reservoir drain is a 24-in. pipe from the gate house with a hand operated valve near the discharge end. This pipe also feeds a 16-in. line to the pump station downstream of the left embankment.

C. Size Classification. Babson Reservoir has an estimated maximum storage of 925 acre-feet and the dam has a maximum height of about 40 feet. Storage of from 50 to 1,000 acre-feet and a height of from 25 to 40 feet classifies a dam to be in the "small" size category, according to guidelines established by the Corps of Engineers

D. Hazard Classification. Babson Reservoir is currently classified as having a "high" hazard potential in the Corps of Engineers National Inventory of Dams. Computations based on "Guidance for Estimating Downstream Dam Failure Hydrograph", included in Appendix D, confirm this classification. In the event of a failure of the dam, the water pumping station, the elderly housing development, and the dense residential district located near the foot of the dam would be completely inundated. Loss of life and excessive economic losses from structural damage would prevail along both sides of the brook from the dam to its outlet into Mill Pond Tidal Basin.

E. Ownership. The name and address of the owner are:

City of Gloucester
Public Works Department
Poplar Street
Gloucester, MA 01930
(Phone: 617/283-5940)

The dam has always been owned by the City of Gloucester. Mr. Robert O'Brien is the current director of the Public Works Department.

F. Operator. Mr. Wilford Burke is the superintendent of the water treatment plant and responsible for the day-to-day operation of the dam. He represented the owner during this investigation. His address and telephone number are the same as the owners, listed above.

G. Purpose of Dam. Babson Reservoir Dam was built and is used for impounding a water supply for the City of Gloucester.

H. Design and Construction History. The Babson Reservoir Dam was designed by Fay, Spofford & Thorndike in 1930 to create a water supply for the City of Gloucester. The scope of work included engineering studies of the Alewife Brook watershed and several test borings.

As indicated by the six test borings shown in Appendix B-9 and later during excavation and construction, the site was underlain by stiff blue clay, glacial till with boulders and bedrock which formed a natural basin. Steel sheeting and a 15-in. thick concrete core wall were used to effect a cut off to rock for the dam. Selected soils and boulders excavated from the reservoir were incorporated into the embankments and used for riprap. The gate house was founded on clay.

Construction of the dam began in July 1930 and was completed in six months by C. & R. Construction. Several contract drawings prepared by Fay, Spofford and Thorndike are included in Appendix B to show details of the original construction.

Flashboards were added as proposed by Metcalf & Eddy in 1950 to increase the capacity of the reservoir. Around 1968, a 30-in. diameter pipeline was constructed from Babson Reservoir to Goose Cove. In 1970 the water treatment plant adjacent to the dam was completed.

I. Normal Operational Procedures. There is no established formal routine for the operation of the dam. The dam, being a water supply dam, is operated according to the demand and supply of water and the funds available for its operation and maintenance.

1.3 PERTINENT DATA

All elevations appearing on drawings and referred to in this report are based on a local datum. To convert from the local datum to National Geodetic Vertical Datum (NGVD), add 3.03 ft. to elevations based on the local datum.

A. Drainage Area. The drainage area of Babson Reservoir is approximately 1,310 acres (2.04 square miles), including the watershed of Cape Pond, water supply for Rockport. The Cape Pond drainage area (Cape Pond is the source of Alewife Brook, the major tributary to Babson Reservoir) comprises an estimated 275 of the total 1,310 acres. Because runoff from the Cape Pond watershed would be tributary to the Babson Reservoir watershed during periods of high runoff, it has been included in the computations for the test flood. The Babson Reservoir pool occupies 40 acres, or 3.1 percent of the total drainage area. The watershed's topography is a mixture of flat and coastal terrain with some moderate hills and swampy areas located adjacent to Alewife Brook.

B. Discharge at Dam Site

- | | |
|--|--------------------------------------|
| 1. Outlet Works..... | 24-in. dia. pipe
at invert El. 24 |
| 2. Maximum known impoundment
at dam site..... | Unknown |
| 3. Ungated spillway capacity
at top of dam..... | 1790 cfs at El.
60.8 |
| 4. Ungated spillway capacity at
test flood pool elevation.. | 1530 cfs at El.
60.2 |
| 5. Gated spillway capacity at
normal pool elevation..... | Not applicable |
| 6. Gated spillway capacity at
test flood pool elevation.. | Not applicable |

7. Total spillway capacity at
test flood pool elevation.. 1530 cfs at El.
60.2
8. Total project discharge at
test flood pool elevation.. 1530 cfs at El.
60.2

C. Elevation (Local datum)

1. Top dam..... 60.8
2. Test flood pool-design
surcharge..... 60.2
3. Design surcharge-original
design..... 58.25
4. Full flood control pool..... Not applicable
5. Water supply pool (full)..... 55
6. Spillway crest
(with flashboards)..... 57.15
(without flashboards)..... 55
7. Upstream portal invert
diversion tunnel..... Not applicable
8. Streambed at centerline of
dam..... 21
9. Maximum tailwater..... Unknown

D. Reservoir

1. Length of maximum pool..... 0.72 mi. (Est.)
2. Length of water supply pool
(full)..... 0.72 mi. (Est.)
3. Length of flood control
pool..... Not applicable

E. Storage (acre-feet)

1. Top of dam..... 925
2. Test flood pool..... 887
3. Flood control pool..... Not applicable
4. Water supply pool (full)..... 635
5. Spillway crest..... 635

F. Reservoir Surface (acres)

1. Top of dam..... 63.5
2. Test flood pool..... 62.5
3. Flood control pool..... Not applicable
4. Water supply pool (full)..... 56
5. Spillway crest..... 56

G. Dam Embankment

1. Type..... Earth
2. Length..... Approx. 630 ft.
3. Height..... Approx. 40 ft.
4. Top Width..... Approx. 15 ft.
5. Side Slopes..... 2.5:1 and 2.75:1
U/S and 2:1 D/S
6. Zoning..... Selected pervious
material downstream
of core wall
7. Impervious core..... Concrete core wall
8. Cutoff..... Concrete core wall
or steel sheet
piling to rock
9. Grout curtain..... None
10. Other..... Core wall drain
and toe drain

H. Diversion and Regulating Facilities. Not applicable.

I. Spillway

1. Type..... Irregular shape
(broad crested weir
with discharge
face sloped 2:1)
2. Length of weir..... 39.75 ft.
3. Crest elevation..... 55.0 (57.15 with
flashboards)
4. Gates..... None
5. U/S Channel..... Approx. 0.15
percent slope
6. D/S Channel..... Approx. one
percent slope

J. Regulating Outlets. The main intake is a 24-in. cast-iron pipe with an invert at El. 24 at the gate house. The pipe feeds a 16-in. intake line to the pump station and a 16-in. bypass line. The capacity of this 16-in. intake line is approximately 40 cfs. At the junction of the 16-in. lines with the 24-in. intake, there is a 24-in. cast-iron blow off line to the stilling basin. The blow off line is controlled by a manually operated gate valve in a manhole at the toe of slope for the dam. During the field inspection, this blow off was shown to be operable.

The intake line is controlled by a manually operated valve in the gate house at the dam crest. There are places for three slots for screens in the gate house.

Two additional methods are available for the purpose of drawing down the level in the reservoir. One is to pump the water into Goose Cove via a 30-in. diameter cast iron pipe utilizing the 4 to 5 mgd capacity pumps located at Goose Cove. The second way is to run the water through the treatment plant at the reservoir via the 16-in. C.I. main.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN RECORDS

An engineering design report, Appendix B-4, and contract drawings for the dam prepared by Fay, Spofford & Thorndike in 1930 are available. The drawings include details of many design features. Correspondence from the Essex County Engineer relates to the spillway stability and design of the flashboards.

2.2 CONSTRUCTION RECORDS

The original construction activities were periodically observed and reported by the Essex County Engineer.

2.3 OPERATION RECORDS

Operation records in the form of reservoir water levels and inspection reports by outside agencies are available on the dam.

2.4 EVALUATION

A. Availability. All of the design, construction and operation records mentioned above and available for use in preparing this report are listed in Appendix B with the locations where they can be found. Selected documents from the listing are also included in Appendix B.

B. Adequacy. The available engineering data when used in combination with the visual examination described in Section 3 were adequate for the purposes of the Phase I Investigation.

C. Validity. The information contained in the engineering data may be generally considered valid. Details on the drawings are shown as designed and may vary slightly from those actually built. For example, the configuration of the channel immediately downstream of the spillway differs from that shown on the drawings.

SECTION 3 - VISUAL EXAMINATION

3.1 FINDINGS

A. General. The Phase I visual examination of the Babson Reservoir dam was conducted on 8 September 1978.

In general, the dam embankment and spillway were found to be in good to fair condition. Some deficiencies which require correction were noted.

A visual inspection check list is included in Appendix A and selected photographs of the project are given in Appendix C.

B. Dam. The earth embankment located right and left of the spillway is generally in good condition. There was no evidence of settlement, lateral movement or other serious defects. Concrete paving on the upstream slope is in satisfactory condition except for localized areas where the concrete has deteriorated. The downstream slope could not be examined closely because of brush and trees.

The following deficiencies were noted:

1. Concrete pavement slabs on the upstream slope have deteriorated in several localized areas, the most severe of which is shown in Photo No. 6. Isolated cracking and minor differential settlement of the slabs relative to the core wall has occurred. The sealant used at the slab joints has broken down and needs replacement. A number of joints now have vegetation. The upstream slope is shown in Photos No. 4 and 5.
2. The downstream slope is covered by trees, brush, weeds and grass. Trees are mature scotch pine from 10 to 15 in. in diameter and spaced 10 to 15 ft. apart. It appears that they were systematically planted. One tree located at the top of slope near the right abutment was blown over and uprooted. Vegetation on the downstream slope is shown in Photos No. 2, 3, 7 and 8 as well as others.
3. Minor seepage in the form of a small (less than 10 ft. square) wet area occurs at the toe of the embankment, approximately 105 ft. left of the spillway. No flowing water was noted. It is understood that this condition has existed for years.

4. Earth fill at the top of the embankment immediately right of the spillway has been eroded by rainfall and foot traffic. The maximum depth is about 3 ft. at the top of the downstream slope. Since the concrete core wall at El. 60.8 forms the top of the dam, minor erosion downstream of the wall is not considered serious.
5. Minor small depressions in the embankment immediately downstream of the core wall were noted. The cause of these depressions is not known, but does not appear to be a result of erosion through joints in the concrete core wall.

The core wall and toe drains discharge into the stilling basin at the toe of the spillway. Both drains were flowing clear. The left drain is shown immediately left of the 24-in. blowoff pipe in Photo No. 11. The outlet of the right drain is submerged, and is located just in front of the observer in Photo No. 12. Coarse gravel and stones cover the end of the pipe.

The exposed portion of the concrete core wall is in good condition. The wall has been patched a number of times and a portion of these patches are now loose. The surface of the wall has eroded and exposed the aggregate. The sealant at the wall joints has broken down and needs replacement. Minor vegetation is present at some of these joints. Other joints have started to break down.

C. Appurtenant Structures. The spillway was found to be in good condition. The approach to the spillway is formed by pavement slabs on the upstream face of the dam, Photo No. 9. The surface of the slabs has eroded and the aggregate is exposed. The sealant at slab joints has broken down. Two logs are present at the entrance to the spillway, Photo No. 9. The impact of these logs against the core wall has caused spalling of the wall. Flashboards on top of the weir are in good condition. The flashboards have been securely bolted to each other and fastened to the training walls. It is questionable whether these flashboards would release under flood conditions.

The downstream side of the spillway, Photo No. 10, is formed by inclined pavement slabs placed on rock fill. The slabs show considerable erosion on the surface. Joint sealant has broken down at the joints and vegetation is present. Cold

joints in the slab have been exaggerated by the erosion. The side walls of the downstream portion of the weir (chute) have been patched. A number of these patches are now loose. Shrinkage cracks and several stress cracks are present in the side walls. Efflorescence is present on the wall surfaces. Considerable erosion has taken place at the downstream end of the chute where it joins the stilling basin. The surface of the chute has stains from the discharge of drain holes in the chute, Photo No. 12.

The side walls of the stilling basin are of reinforced concrete. The left side wall shows considerable cracking and efflorescence. This wall should be considered in good to fair condition. The right side wall shows minor cracking and some efflorescence. This wall is in good condition. The end walls of the stilling basin are of cut stone masonry. One small section of this wall, on the left side where it joins the downstream channel, is on the verge of collapse. The rest of the cut stone masonry wall is in good condition with some open joints.

The gate house, Photo No. 14, is in good condition. The superstructure is of cut stone masonry. One crack was noticed in the stone work on the left side of the gate house. Metal work in the form of ladders, railings, hatches and screen guides show considerable deterioration. Hatches have been removed from the openings they once covered. This metal work is considered to be in good condition. The exterior surface of the concrete has been eroded to expose the aggregate at the water line. The interior surfaces of the concrete show cracking and efflorescence.

The service bridge to the gate house is in good condition except for the concrete support brackets at the gate house end. The two brackets show considerable cracking and loose concrete. These brackets should be considered in poor condition.

All railings observed on the service bridge and within the gate house are considered to be in poor condition. Major portions of these railings are missing. The remaining portions show considerable deterioration.

D. Reservoir Area. The area around Babson Reservoir is generally wooded with irregular topography and rock outcrops. There are no conditions which would lead to a significant increase in sediment load to the reservoir or landslides which would cause waves to overtop the dam.

E. Downstream Channel. The channel downstream of the stilling basin is shown in Photo No. 13. It is a narrow channel formed by stone masonry walls and differs from the 48 ft. wide "ditch" shown on the drawing in Appendix B-9. The channel is discussed further in Section 5.

3.2 EVALUATION

Based on visual observations during the site examination, the general condition of the project is satisfactory. Deficiencies which have been noted should not have a serious effect on the performance or safety of the dam.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

In general, there are no formal procedures to assure regular maintenance and satisfactory operation of the dam. The current dam operator attempts to keep an adequate water supply in the reservoir by pumping water to or from Goose Cove Reservoir.

4.2 MAINTENANCE OF DAM

There are no established procedures to assure periodic inspection and maintenance of the dam. A maintenance crew from the Gloucester Public Works Department is available to perform work when requested.

4.3 MAINTENANCE OF OPERATING FACILITIES

The operation of the facility is based on the demand and supply of water rather than any formal established operational procedures.

The outlet from the dam does not receive regular maintenance, but is operational. However, the gates appear to have received limited maintenance.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

There is no formal warning system or emergency preparedness plan in effect for this structure.

4.5 EVALUATION

The current operation and maintenance procedures for Babson Reservoir are inadequate for a high hazard structure of this size. An annual inspection and maintenance program should be developed to remedy deficiencies before they become a threat. In addition, the City of Gloucester should establish a formal written emergency preparedness plan and warning system, since failure of the dam would cause loss of life and extensive property damage.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

A. Design Data. A set of plans entitled "Alewife Dam and Reservoir - Gloucester, Mass." bearing the date of June, 1930 were the basis for the construction of this facility. The reservoir was constructed in order to augment the City's water supply and was designed for a safe yield of 1 MGD. Hydraulic design data developed by Fay, Spofford, and Thorndike indicate that the spillway had been designed for a flow of 800 cfs. for a depth of flow of 3.25 ft. over the weir. However, the total freeboard of the dam above the weir level was designated to be 6 ft. for safety. The reservoir's inflow was computed using the Rational Method on the basis of a 2.25 square mile drainage area. However, because of land use changes and the construction of man-made drainage divides (i.e. Route 128), the present size of the watershed is approximately 2.04 square miles.

The recommended test flood for the size (small) and hazard potential (high) of this dam is in the range of the one-half probable maximum flood (1/2 PMF) to the probable maximum flood (PMF).

B. Experience Data. The PMF was determined using the chart prepared by the Corps of Engineers, New England Division in the Guidelines. Assuming flat and coastal terrain, the PMF is 1740 cfs. By taking advantage of surcharge storage, this peak is decreased to 1530 cfs. Because the water surface area is an estimated 3.05 percent (40 acres) of the total drainage area, flood routing techniques were not deemed worthwhile. The spillway will discharge the peak flow of 1530 cfs. with the reservoir water surface at El. 60.2, 0.6 ft. below the top of the concrete core wall.

C. Visual Observations. The inspection revealed that no significant modifications have been made to the inlet or outlet works since the construction of the dam, with the exception of the channel immediately downstream which is of man-made origin with vertical stone masonry walls. Approximately 62 ft. downstream of the dam's stilling basin, there exists a 60-inch diameter concrete pipe which carries the flow for an estimated 41 ft. at which point the stone channel resumes, Photo No. 13.

Approximately 260 ft. further downstream, the brook is conveyed in twin 48-inch concrete pipes under the road leading to the elderly housing project. After this point, the brook flows in a natural earth channel with cobbles and dense vegetation encroaching upon it. It is confined to culverts under the private way on the westerly side of the housing project (twin 36-in. diameter and one 12-in. diameter concrete pipes) under Cherry Street (36 in. x 58 in. C.M. Plate Arch) and under the D.P.W. Yard (48-in. diameter concrete pipe). It empties into what appears to be a tidal flood basin on the westerly side of the D.P.W. Yard and eventually into Mill Pond.

D. Overtopping Potential. As stated previously, based on the size (small) and hazard (high) classifications published in the Guidelines, the test flood falls in the range of the 1/2 PMF to the PMF. However, because of the elderly housing located in such close proximity to the base of the dam, as well as the surrounding dense residential district, the test flood has been designated the PMF. A rating curve for the dam's spillway was developed, and demonstrated that the spillway was capable of handling approximately 1790 cfs with the flashboards removed. Therefore, since the value of the PMF is 1530 cfs, it is estimated that the spillway can pass the test flood with 0.6 ft. of freeboard remaining.

E. Evaluation. As stated previously, the spillway is capable of handling the PMF. However, a failure of this dam would result in extensive downstream damage and loss of life would be unavoidable. The degree of this damage would lessen as one approached Mill Pond Tidal Basin. However, the high hazard potential from this flow would still exist until it entered the tidal basin. At this point, the available storage in the basin would most likely contain the flow.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF EMBANKMENT STRUCTURAL STABILITY

A. Visual Observations. There was no visual evidence of instability of the earth embankment during the site examination on 8 September 1978. However, it was not possible to closely examine the downstream slope because of dense vegetation.

B. Design and Construction Data. A theoretical analysis of the structural stability of the embankment slopes was not possible due to lack of pertinent design and construction data, in particular with reference to the properties of earth materials placed in the embankment. Nevertheless, since the embankment is only 40 ft. high, has a 2 horizontal to 1 vertical downstream slope and a central concrete core wall to rock and internal drains, the embankment slope can be expected to be stable under static loading conditions. Upstream slopes of 2.5:1 and 2.75:1 are reasonably flat.

C. Operating Records. No operating records or measurements from field instrumentation are known to exist for this dam.

D. Post-Construction Changes. There are no known post-construction alterations or additions to the project which affect embankment stability.

E. Seismic Stability. Babson Reservoir is located in Seismic Zone 3. The stability of the embankment slopes during an earthquake is unknown. Settlement of the crest and down-slope movements during a seismic event are a function of foundation soils below the embankment and properties of embankment materials. These conditions should be determined and stability analyses made using conventional equivalent static load methods.

6.2 EVALUATION OF SPILLWAY STRUCTURAL STABILITY

A. Visual Observations. There was no visual evidence that movement or distress had taken place in the spillway.

B. Design and Construction Data. Design data in the form of construction plans are available on the spillway. A letter from the design engineers shown in Appendix B-7 states that the spillway as originally designed would have a stability "factor of safety of at least four".

The spillway is formed by concrete pavement slabs over rock fill on a 2:1 slope. The structural stability of the spillway is, therefore, dependent on the stability of the rock fill. Rock fill on a 2:1 slope, confined by concrete walls, can be expected to be adequately stable under static loads.

C. Operating Records. No records or other information was located which indicated stability problems with the spillway.

D. Post-Construction Changes. Although flashboards were added to the spillway after the original construction, there have been no post-construction structural alterations to the spillway.

E. Seismic Stability. The stability of this spillway under earthquake loading is dependent upon the seismic stability of rock fill which supports the concrete pavement slabs. While a Zone 3 earthquake event would cause some shifting and possible downslope movement of boulder fill and thus damage to the spillways, it is unlikely that the spillway would suffer a catastrophic failure.

SECTION 7 - ASSESSMENT, RECOMMENDATIONS AND REMEDIAL MEASURES

7.1 DAM ASSESSMENT

A. Condition. The visual examination of the Babson Reservoir dam revealed that the embankment and spillway are generally in good to fair condition. There were no obvious signs of failure or other conditions which would warrant urgent remedial treatment.

Based on the results of computations included in Appendix D, the spillway is capable of passing the test flood, which is based on the probable maximum flood, with 0.6 ft. of freeboard remaining.

B. Adequacy of Information. The information available concerning the design and construction of the dam are adequate for a Phase I Investigation when supplemented by field observations.

C. Urgency. The recommended additional investigation and remedial work outlined in Section 7.2 and 7.3 should be undertaken by the Owner and completed within 24 months after receipt of this Phase I Inspection Report.

D. Need for Additional Investigation. An additional investigation is required, as outlined in the following section.

7.2 RECOMMENDATIONS

It is recommended that the Owner engage a registered professional engineer experienced in dam design to undertake an investigation of embankment stability under earthquake loading conditions for Seismic Zone 3.

7.3 REMEDIAL MEASURES

A. Alternatives. Not Applicable.

B. Operating and Maintenance Procedures. The following remedial work should be undertaken by the City of Gloucester:

1. Cut and remove trees on the downstream slope of the embankment. Stumps may be cut flush with the ground and left in place. Remove all brush and cut grass

and weeds. For the future, the downstream slope should be mowed at least once a year to limit the height of vegetation and allow for visual examination of the embankment.

2. Place earth fill in shallow depressions at the top of the embankment adjacent to the concrete core wall. Place earth fill immediately right of the spillway where erosion has occurred, to restore embankment cross-section to the original design geometry.
3. Clear debris from the stilling basin below the spillway, in particular in the area of the underdrain discharge pipe on the right side. The pipe should flow freely without obstruction.
4. Repair the concrete support brackets at the gate house end of the service bridge.
5. Renew railings at this facility.
6. Renew gratings, hatches and ladders within the gate house structure.
7. Reseal all joints in the concrete pavement on the upstream slope, exposed core wall and spillway. Remove all loose concrete patches, fill all resultant voids, spalls, and missing pieces of pavement with concrete.
8. Resurface the chute portion of the spillway with shotcrete, mortar or other materials to prevent further deterioration of the spillway.
9. Repair the cut stone masonry wall at the entrance to the discharge channel.

Due to the "high" hazard potential classification, the Owner should establish a formal operations and maintenance manual for this dam. The operating procedure should include provisions for biennial technical inspection of the dam and for surveillance of the dam during periods of heavy precipitation and high reservoir water levels. The procedures should delineate the maintenance work to be done on the dam to ensure satisfactory operation and to minimize deterioration of the facility.

The Owner should develop a formal emergency preparedness plan and warning system to be used in the event of impending failure of the dam. The system should be developed in cooperation with other local officials and downstream inhabitants.

APPENDIX A
INSPECTION TEAM ORGANIZATION AND CHECK LIST

	<u>Page No.</u>
<u>VISUAL INSPECTION PARTY ORGANIZATION</u>	1
<u>VISUAL INSPECTION CHECK LIST</u>	
Dam Embankment	2
Outlet Works - Approach Channel, Spillway Weir, Stilling Basin and Discharge Channel	4
Outlet Works - Gate House	5

VISUAL INSPECTION PARTY ORGANIZATION

NATIONAL DAM INSPECTION PROGRAM

Dam: Babson Reservoir

Date: 8 September 1978

Time: 0900-1430

Weather: Clear and Cool (50's F.)

Water Surface Elevation Upstream: 51.45 (local datum)

Stream Flow: Negligible

Inspection Party:

Harl P. Aldrich, Jr.	- Soils/Geology
Haley & Aldrich, Inc.	
Roger H. Wood	- Structural/Mechanical
Camp, Dresser & McKee, Inc.	
Charles E. Fuller	- Hydraulic/Hydrologic
Camp, Dresser & McKee, Inc.	

Present During Inspction:

Wilford Burke, Chief of Treatment Plant
Richard A. Brown, Haley & Aldrich, Inc.
Donna D'Amore, Camp, Dresser & McKee, Inc.

VISUAL INSPECTION CHECK LIST

NATIONAL DAM INSPECTION PROGRAM

DAM: Babson Reservoir DATE: 8 Sept 78

AREA EVALUATED	CONDITION
<u>DAM EMBANKMENT</u>	
Crest Elevation	60.0 (local datum); Top of concrete core wall El. 60.8
Current Pool Elevation	51.45
Maximum Impoundment to Date	Unknown
Surface Cracks	None observed
Pavement Condition	No pavement
Movement or Settlement of Crest	None observed, except for numerous small shallow depressions adjacent to concrete core wall
Lateral Movement	None observed
Vertical Alignment	Good (top of concrete wall slightly uneven, by 1 to 2 in. in places)
Horizontal Alignment	Good
Condition at Abutment and at Concrete Structures	Conditions at abutments good; good immediately left of spillway; right of spillway, adjacent to wall, there has been erosion by rainfall and foot traffic up to 3 ft. depth, 4 ft. wide, at downstream side of crest
Indications of Movement of Structural Items on Slopes	No structural items on slopes
Trespassing on Slopes	Frequent at crest of dam and upstream slope, although area is posted
Animal Burrows in Embankment	None observed, but downstream slope difficult to examine because of vegetation
Vegetation on Embankment	Top of embankment is grass, mowed; trees, brush, weeds and grass on downstream slope including mature scotch pine from 10 to 15-in. diameter spaced 10 to 15 ft. apart
Sloughing or Erosion of Slopes or Abutments	Minor, but some at contact with spillway
Rock Slope Protection - Riprap Failures	No riprap; upstream slope is paved with a 6 in. reinforced concrete slab above El. 45; The surface of the concrete pavement has eroded and the aggregate is exposed. There is differential settlement

FILE NO. 4160

VISUAL INSPECTION CHECK LIST NATIONAL DAM INSPECTION PROGRAM

DAM: Babson Reservoir

DATE: 8 Sept 78

AREA EVALUATED	CONDITION
Rock Slope Protection - Riprap Failures (Cont.)	of the pavement slabs. Joints are in need of new sealant. There are a number of joints with minor vegetation present. There are isolated instances of broken slabs and small missing portion of pavement slabs
Unusual Movement or Cracking at or near Toes	None observed
Unusual Embankment or Downstream Seepage	Small wet area (less than 10 ft. square) at toe of embankment about 105 ft. left of spillway, no flowing water; another moist area nearby downstream toe.
Piping or Boils Foundation Drainage Features and Toe Drains	None observed 6-inch vetrified clay drains immediately downstream of concrete core wall and at toe of embankment, discharge into spillway stilling chamber; water flowing from both pipes.
Instrumentation Systems Exposed Concrete Core Wall	None The exposed portion of the core wall has been patched in a considerable number of places. A number of these are now loose. Vertical cracks and efflorescence are present. The surface has eroded and exposed the aggregate. Joints have been sealed but it needs to be renewed. Breakdown of the concrete is occurring at some of the joints. There are isolated instances of vegetation in the joints. The major portion of the railing on top of the wall is missing; the remaining portion is in disrepair

FILE NO. 4160

NATIONAL DAM INSPECTION PROGRAM

DAM: Babson Reservoir

DATE: 8 Sept 78

AREA EVALUATED	CONDITION
<p><u>OUTLET WORKS - APPROACH CHANNEL, SPILLWAY WEIR, STILLING BASIN AND DISCHARGE CHANNEL</u></p> <p>a. <u>Approach Channel</u></p> <p>General Condition</p> <p>Log Boom</p> <p>b. <u>Weir and Training Walls</u></p> <p>General Condition of Concrete</p>	<p>Good condition. The channel is formed by pavement slabs which exhibit surface erosion. Sealant at joints has broken down and needs replacement</p> <p>Two logs are present; one is an irregular tree trunk. This one appears susceptible of breaking at the small diameter end and becoming lodged in the spillway. The impact of the booms have caused spalls in the core wall</p> <p>Good condition. The weir is formed by inclined pavement slabs. The downstream portion of the weir has an eroded surface, breakdown of construction and cold joints, and vegetation in the joints. The sidewalls have been patched. Some of the patches are now loose. The sidewalls have shrinkage cracks and a few stress cracks. Earth has eroded from behind the right side wall. Stains from exposed tie wires are present on the back face of this wall. Considerable erosion and deterioration occurs where the downstream end of the weir or chute joins the stilling basin. This portion of the weir is stained by discharge from the drainholes. Efflorescence is present on the side walls. The flashboards on the weir are in good condition</p>

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HALEY & ALDRICH, INC.

VISUAL INSPECTION CHECK LIST

NATIONAL DAM INSPECTION PROGRAM

DAM: Babson Reservoir DATE: 8 Sept 78

AREA EVALUATED	CONDITION
Drain Holes	Drain holes on spillway slope are generally open. Three of four located at the toe are flowing
<p>c. <u>Stilling Basin</u></p> <p>General Condition</p>	<p>The left side wall shows many cracks and considerable efflorescence. The right side wall shows little cracking and some efflorescence. The end wall is cut stone masonry with some open joints. One small area of this wall where it becomes the left side wall of the discharge channel is almost completely broken down. The basin contains considerable soil reported to have been washed down from the dam embankment. The blowoff pipe as well as the underdrains from the dam discharge into the stilling basin. All pipes appear to be clear to drain although one of the underdrain outlets is presently below the silted area. Bottom of basin has automobile tires and other debris</p>
<p>d. <u>Discharge Channel</u></p> <p>General Condition</p>	<p>Narrow vertical channel formed by stone masonry walls. Generally free of vegetation and debris. See text of report and photographs</p>
<u>OUTLET WORKS - GATE HOUSE</u>	
<p>a. <u>Approach Channel</u></p>	<p>The outlet works is adjacent to the reservoir; no approach channel present</p>

FILE NO. 4160

VISUAL INSPECTION CHECK LIST

NATIONAL DAM INSPECTION PROGRAM

DAM: Babson Reservoir

DATE: 8 Sept 78

AREA EVALUATED	CONDITION
<p>b. <u>Gate House Structure</u></p> <p>General Condition</p>	<p>Good condition; the stone masonry superstructure has one noticeable crack in stone work. Windows and doors need replacement. Interior metal work especially ladder, hatches and guides for screens need replacement. Other interior metal work needs re-painting. The concrete sub-structure shows erosion on the exterior surfaces at the water line. Efflorescence and cracking was observed on the interior side. There is debris present on the gate house floor</p>
<p>c. <u>Bridge to Gate House</u></p> <p>General Condition</p>	<p>The concrete bridge is in good structural condition other than the concrete support brackets at the gate house end. The brackets indicate sever cracking and need for rebuilding. The bridge railing is in need of replacement</p>
<p>d. <u>Mechanical and Electrical</u></p> <p>Reservoir Gauge</p> <p>Hoist</p> <p>Service Gates</p> <p>Lightning Protection System</p> <p>Emergency Power System</p> <p>Wiring and Lighting System in Gate Chamber</p>	<p>The mechanical float gauge is operable; reservoir level indicated by pointer on circular dial</p> <p>The hoist is operable but needs repainting</p> <p>The service gates are operable but need repainting</p> <p>None observed</p> <p>None</p> <p>Conduits and outlets have rust present. It is presently operable but its condition is only considered fair. It should be renewed</p>

FILE NO. 4160

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Babson Reservoir DATE: 8 Sept 78

AREA EVALUATED	CONDITION
e. <u>Outlet Pipeline</u>	The pipeline is not visible for inspection

APPENDIX B
LIST OF AVAILABLE DOCUMENTS AND
PRIOR INSPECTION REPORTS

	<u>Page No.</u>
<u>LIST OF AVAILABLE DOCUMENTS</u>	1
<u>SELECTED DOCUMENTS</u>	
Text of design report by Fay, Spofford & Thorndike, Inc., Boston, MA, 31 May 1930	4
Letter regarding adequacy of spillway stability design, Fay, Spofford & Thorndike, Inc., Boston, MA, 3 November 1930	7
Contract drawings - Alewife Dam and Reservoir, Sheets 2 and 3, June 1930	9
<u>PRIOR INSPECTION REPORTS</u>	
Letter report on the 13 construction inspections from 22 July 1930 through 4 December 1930 by the Essex County Engineer	11
Summary reports on the 26 inspections from 21 January 1931 through 31 March 1968 by the Essex County Engineer	13
15 July 1971 report by the Mass. Department of Environmental Quality Engineering	20